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Phenotypic characteristics of carcass quality traits of indigenous pig breeds and their hybrids

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Abstract: The research in this work is related to the traits carcass and meat quality of the pure breeds of Mangalitsa (G1; Swallow belly strain) and Moravka (G2) as well as their hybrids of the F_1 generation (G3). Ten (10) animals were examined per genotype and both sexes were included for each genotype. For the tested genotypes, the average weight of the warm carcass side for G1 was 98.6 kg, G2 97.4, and G3 98.83 kg. The average weight of the four major carcass side parts - the leg (MH), shoulder (MS), loin rump part (MLB) and abdominal rib part (AR) for the tested genotypes (G1, G2 and G3) was 9.68 kg, 9.46 kg and 9.39 kg; MS 5.51 kg, 5.69 kg and 5.63 kg; for MLB 7.69 kg, 7.76 kg and 8.00 kg, while for AR the average weight of the part was determined to be 5.53 kg, 5.77 kg and 6.23 kg, respectively. The estimated total yield (JUS kg) and the share of meat (JUS %) in carcass sides (OG SFRY, 1985) was for G1 27.84 kg, for G2 28.91 kg and for G3 28.64 kg of meat, while the estimated meatiness was 28.60%, 29.96% and 29.42%. Genotype as a source of variation in carcass quality traits did not influence ($p>0.05$) the variation of examined carcass quality traits except for the surface, depth, and pH_{45} of *M. longissimus dorsi* (MLD; $p<0.05$). Genotype also had an influence on the colour of *MLD* (L* and b*; $p<0.001$). The pH_{45} and pH_{24} values of *M. semimembranosus* and pH_{24} *of MLD* indicated normal meat and were not influenced by genotype or gender ($p>0.05$). Gender had an influence on the surface of the back fat ($p<0.05$), whereas for other sources of variation in carcass quality traits gender did not influence.

Keywords: Mangalitsa; Moravka; pig; meatiness; meat pH; meat colour

INTRODUCTION

In recent years, interest in autochthonous breeds has increased not only for the purpose of preserving their genes, but also for production meat „healthy meat“ from the ecological and organic pig production system. The animals are exclusively reared in free-range conditions, have considerably higher body fat content than other conventional lean pig breeds, possess unique sensory characteristics of meat, and are used for manufacturing of high-quality meat products (Popova et al., 2015). Obtaining raw materials for the production of traditional dry meat products (ham, kulen sausage, bacon, pork skin crackling, etc.), first of all for agricultural farms engage in pig breeding and in rural tourism. Meat and meat products represent an important part of the human diet, because they are rich and convenient sources of substances necessary for the normal functioning of the body. The meat of autochthonous pig breeds is darker in colour (especially Mangalitsa), contains a higher percentage of fat, has a stronger smell and is juicier, compared to the meat of commercial pig breeds.

Mangalitsa is typical fatty pig breed, it has in carcass sides 65 - 70% of fat and approx. 28 % meat (Petrović et al., 2009). Mangalitsa, Moravka and Resavka are animal genetic resources and autochthonous breeds of pigs in the Republic of Serbia. The largest populations in our country are made up of the Mangulitsa and Moravka breeds, while the third local breed Resavka is critically endangered with an extremely small population. Moravka and Resavka are breeds of combined production abilities. Moravka has somewhat more meat with bones in carcass sides and considerably less fat than Mangalitsa (Živković and Kostić, 1952a, b). Traits of pigs of Moravka breed (body development, reproductive and fattening traits), identification, selection of heads and forming of herd, are presented in detail in paper by Petrović et al. (2005, 2007a). Climate change and the emergence of new animal diseases emphasize the need to maintain and conserve plant and animal resources because of their adaptive capacity. For hundreds of millions of poor rural households, livestock production and crop farming are a key resource for life. Livestock production has great contribution and is vitally important for the life and safety of crop production.

MATERIAL AND METHODS

The research in this work is related to the properties of growth, carcass and meat quality of the pure breeds of Mangalitsa (G1; Swallow belly strain) and Moravka (G2) as well as their hybrids of the F_1 generation (G3). Ten (10) animals were examined per genotype and both sexes (male castrates-surgical castration) were included for each genotype. A traditional low-input technology was applied. Apart from pasture, the pigs were given of corn (to 0.3 kg/animal/day). Meatiness was established using partial dissection (EC No 3127/94, 1994 and EC No 1197/06), Two-point (TP) method and method Fat-O-Mater (FOM). Two-point method as follows: fat thickness was measured at the thinnest point of the rump, i.e. where *M.gluteusmedius* (MGM) penetrated the fat tissue the most (S) and the second measure was depth of *Musculus longissimus* (ML) measured as the shortest link/connection between the front (cranial) end of the MGM and the top (dorsal) rim/edge of the spinal canal (M). Method Fat-O-Mater is determined by simulating the instrumental method (FOM): measuring the thickness of back fat with skin in millimetres 7 cm from the medial line between the 2nd and 3rd last rib (RF), measuring ML muscle depth (RM) at the same point, and measuring the thickness of back fat with skin in millimetres 8 cm from the medial line between the 3rd and 4th lumbar vertebra (LF). Estimated meatiness is determined by the both methods (TP and FOM) using the formula mentioned by Radović et al. (2010). For determination of yield and share of meat in carcass sides, based on carried out measuring, tables for fatty pigs were used which are integral part of the Rulebook on quality of slaughtered pigs and categorization of pig meat (OG SFRY, 1985). Meat value pH ML and *M. semimembranosus* (SM) was determined 45 minutes (pH1) and 24 hours post mortem (pH2) by pH-meter (Hanna, HI 83141). The print/mark of the long back muscle ML and fat was taken (between 13th and 14th rib) on tracing paper to determine the eye muscle area (AML) and fat areas which associated muscle (FA). The color of ML was determined 24 hours *post-mortem* measured at the same position as RF and RM (between 3rd and 4th rib, from caudo-cranial point of view) using Chromameter CR-400 (Minolta Co. Ltd, Tokyo, Japan). The measurements were done according to CIE L*a*b* system: lightness (L*), redness (a*) and yellowness (b*).

Descriptive statistics were calculated using the SAS software package (SAS, Inst. Inc. 2011: The SAS System for Windows, Release 9.4.), and using the MEANS procedure. In order to determine the differences between groups of animals, the statistical procedure TTEST we calculated also within the SAS software package (SAS, Inst. Inc. 2011: The SAS System for Windows, Release 9.4.).

RESULTS AND DISCUSSION

In Table 1, we see that the Mangalitsa (G1; Swallow belly strain) animals had a lower daily life gain compared to the Moravka pigs (G2) as well as their hybrids of F_1 generation (G3) by -45 g and -39 g, respectively. The back fat thickness was greater in G1 animals, which was to be expected, because it is a fatty breed of pigs. Females showed higher growth and thicker back fat (BF1 and BF2). The determined differences between genotypes and sexes for the mentioned traits were not statistically significant (P>0.05).

In a study by Radović et al. (2017a), the same genotypes (G2 and G3) with a higher pre-slaughter weight (134.8 kg and 128.7 kg) had a higher average daily gain (369 g and 337 g), while the heads of the Mangalitsa breed (G1) achieved a lower gain (268 g) compared to our research. In the mentioned research, higher values were determined for the back fat thickness BF1 and BF2 compared to our results. Radović et al. (2017b), in their study of Swallow belly Mangalitsa (in the fattening period from 24 kg to 115.5 kg) and Moravka (in the fattening period from 29.9 kg to 131.3 kg) on ad libitum feeding with a complete mixture with 13 - 15% crude protein, state that the Mangalitsa achieved an average daily gain of 480 g and the Moravka - 545 g. The maximum growth rate observed for Mangalitsa was 690 g and for Moravka - 607 g, in the period corresponding to average body weight (end of period) of 79 and 89 kg, respectively. In the research by Petrović et al. (2007b), with the average pre-slaughter body weight of heads of 125.06±24.82 kg compared to our research, higher values were found for the trait of back fat thickness for genotype G1 (72.3:65.2 mm) and for genotype G2 (58.7:57.4 mm), while for G2 lower values were found for back fat thickness in the middle of the back. (35.1:43.2 mm). In a closed system, individually in 12.2 m^2 pens and with fed a typical grower ration (17% CP) from 18 to 54 kg body weight (BW) and a finisher ration (15% CP) from 55 to 110 kg. Roberts et al. (2023) determined not much higher daily gains for the Swallow-bellied Mangalitsa pigs compared to our research (from 18 kg to 110 kg daily gains 400 g : 313 g daily life gain) as well as back fat on the middle of the back (58.7 mm : 50.1 mm).

Table 2 shows the average weight of the basic parts of the carcass side with the addition of the weight of the fillet, on the basis of which the estimated meatiness of EC94 and EC06 was calculated. There was no influence (P>0.05) of the examined factors on the determined average weight values of individual parts.

The estimated yield and proportion of meat and meatiness as well as the two values S and M, used to calculate the meatiness of TP, are shown

Table 1. Influence of genotype and gender on body weight, the growth and backfat thickness

Variation source		BW[3], kg	WHC, kg	ADG, g	BF_1, mm	BF_2, mm	BF_3, mm
$\bar{X}$± SD		118.6 ±19.6	98.3±16.6	341±62	62.1±12.6	46.6±10.3	47.5±8.6
G1[1]		119.7 ±21.3	98.6±18.5	313±42	65.2±11.1	50.1±11.9	51.4±8.5
G2		118.9 ±23.5	97.4±19.3	358±70	57.4±15.6	43.2±10.1	44.6±9.5
G3		117.2 ±14.8	98.8±13.2	352±66	63.7±10.5	46.4±8.3	46.5±7.0
P		NS[4]	NS	NS	NS	NS	NS
Sex	M[2]	115.4 ±18.3	96.5±16.8	316±45	61.8±11.5	46.8±11.9	47.6±6.8
	F	121.0 ±20.7	99.7±16.9	359±68	62.4±0.02	47.4±10.0	47.4±10.0
P		NS	NS	NS	NS	NS	NS

[1] G1-Mangalitsa (MNG), G2- Moravka (MO), G3- MNGxMO;
[2] M-male castrates, F-females;
[3] BW-Preslaughter mass, WHC- warm carcass weight, ADG- daily life gain, BF_1-backfat on the ridge, BF_2-backfat on the middle of the back, and BF_3-backfat on the rump;
[4] NS=P>0.05.

Source: Authors' own elaboration

in Table 3. The highest values of estimated meatiness were determined using the TP method from 35.5% (genotype G1) to 37.3% (genotype G3). Genotype G2 had higher estimated meatiness of EC94 (32.9%) and EC06 (34.9%) compared to G1 and G3. No statistically significant differences (P>0.05) were found for the properties examined in Table 3. The research by Petrović et al. (2007b) shows an identical share of meat in carcass sides of 30% for G2 as in our research, and lower share of meat for G1 by 3.8%. In relation to our research, Petrović et al. (2007b) show lower values of meat yield in carcass sides for G1 (25.49:27.8 kg) and for G2 (28.71:28.9 kg).

In relation to G1 and G3 (Table 4), a higher value of the eye muscle area was found in the animals of genotype G2 (AML; 29.3 cm^2). The determined difference between the genotypes for the specified trait was statistically significant (P<0.05). A statistically significant difference (P<0.05) between genotypes and gender was also found for the RM value. Gender also had a significant effect (P<0.05) on the trait fat surfaces of the associated muscle (FA; 56.2:50.2 cm^2).

Table 2. Influence of genotype and sex on the weight of basic carcass side parts and fat (F)

Variation source		MH[3], kg	MS, kg	MLB, kg	AR, kg	F, kg
$\bar{X}$ ± SD		9.51 ±1.8	5.61±0.9	7.82±1.2	5.84±1.3	2.32±0.7
G1[1]		9.68 ±2.0	5.51±1.0	7.69±1.5	5.53±1.1	2.12±0.5
G2		9.46 ±1.9	5.69±1.0	7.76±1.4	5.77±1.7	2.16±1.0
G3		9.39 ±1.7	5.63±0.9	8.00±0.7	6.23±1.2	2.70±0.5
P		NS[4]	NS	NS	NS	NS
Sex	M[2]	9.39 ±2.0	5.45±0.9	7.61±1.1	5.57±1.3	2.20±0.6
	F	9.61 ±1.7	5.74±1.0	7.98±1.3	6.05±1.3	2.42±0.8
P		NS	NS	NS	NS	NS

[1] G1-Mangalitsa (MNG), G2- Moravka (MO), G3- MNGxMO;
[2] M-male castrates, F-females;
[3] MH-leg weight, MS-shoulder weight, MLB-weight of loin-rump art, AR-weight of belly-rib part, F-weight of backfat
[4] NS=P>0.05.

Source: Authors' own elaboration

Table 3. Influence of genotype and gender on the carcass quality traits

Variation source	JUS[3], kg	JUS, %	S, mm	M, mm	TP, %	EC94, %	EC06,%
$\bar{X}$ ± SD	28.6±4.1	29.4±1.7	44.5±11.2	57.6±7.0	35.5±7.8	31.8±3.2	34.1±3.7
G1[1]	27.8±3.9	28.6±1.8	46.2±15.0	58.1±5.4	35.5±7.8	31.3±2.1	34.0±1.9
G2	28.9±5.0	30.0±1.6	43.6±11.3	58.3±6.1	37.0±6.2	32.9±4.2	34.9±5.1
G3	29.2±3.8	29.7±1.4	43.7±7.2	56.3±9.4	37.3±4.6	31.0±3.2	33.4±3.9
P[4]	NS	NS	NS	NS	NS	NS	NS
Sex M[2]	28.2±4.6	29.4±1.7	43.1±9.5	55.7±7.3	37.3±5.2	31.6±3.2	33.8±3.5
F	29.0±3.9	29.4±1.7	45.5±12.6	59.0±6.6	36.0±7.0	31.9±3.4	34.3±4.1
P	NS	NS	NS	NS	NS	NS	NS

[1] G1-Mangalitsa (MNG), G2- Moravka (MO), G3- MNGxMO;
[2] M-male castrates, F-females;
[3] JUS- yield of meat, S- fat thickness, M- depth Longissimus muscle; JUS, TP, EC94, EC06- estimated meatiness;
[4] NS=P>0.05.

Source: Authors' own elaboration

For the autochthonous Croatian breed Crna Slavonska pig (a breed with combined production properties such as Moravka), in an open breeding system (equal number of gilts and barrows, with approximately 130.00 kg live weight at the age of 18 months), Kušec et al. (2017) determined lower value for the back fat thickness (S) 37.75 mm and higher value M for the muscle thickness 71.53 mm (according to "Two points" method) than our research (43.6 mm and 58.3 mm). In the same research, Kušec et al. (2017) in relation to our research for genotype G2, determined that Crna Slavonska have higher value for the AML (32.53 cm^2:29.3 cm^2) and lower value for the FA (31.90 cm^2:50.4 cm^2). Compared to the research of Petrović et al. (2007b) and Radović et al. (2017a), in our study for G1 lower values were found for AML (24.43 cm^2 and 24.16 cm^2) and higher value FA (81.35 cm^2 and 55.88 cm^2), although the animals had a higher average pre-slaughter body weight (133 : 125 kg). For G2 genotype, Petrović et al. (2007b) and Radović et al. (2017a) show lower values for the AML trait (24.78 cm2 and 28.51 cm^2), while for FA, Petrović et al. (2007b)

Table 4. Influence of genotype and gender on the carcass quality traits (part two)

Variation source	AML[3)], cm^2	FA, cm^2	LF, mm	RF, mm	RM, mm	FOM,%
$\bar{X}$ ± SD	27.8±2.5	53.6±9.4	50.1±10.6	49.1±12.3	43.2±6.0	29.1±8.7
G1[1)]	26.2±1.9	58.3±13.1	51.5±12.3	53.0±14.2	41.1±4.0	25.5±9.5
G2	29.3±2.0	50.4±7.8	47.5±12.0	43.4±12.0	44.0±5.9	31.4±8.4
G3	27.9±2.8	52.1±4.3	51.3±7.4	50.9±9.4	44.5±7.5	30.3±8.0
P[4)]	*	NS	NS	NS	*	NS
Sex M[2)]	27.4±2.6	50.2±9.4	47.9±8.3	48.5±9.5	40.3±5.5	30.8±7.5
F	28.1±2.5	56.2±8.9	51.8±12.1	49.5±14.4	45.4±5.4	27.7±9.6
P	NS	*	NS	NS	*	NS

[1)] G1-Mangalitsa (MNG), G2- Moravka (MO), G3- MNGxMO;
[2)] M-male castrates, F-females;
[3)] AML-eye muscle area, FA-fat areas which associated muscle, LF-fat tissue thickness and RF-fat tissue thickness and RM Depth Longissimus dorsi muscle (FOM measurement points for simulating the instrumental method), FOM- estimated meatiness;
4) NS=P>0.05; *=P<0.05
Source: Authors' own elaboration

Table 5. The effect of genotype and sex on the on the pH value and colour of the muscle

Variation source	pH_{45}- ML[3)]	pH_{45}-SM	pH_{24}- ML	pH_{24}-SM	L^*	a^*	b^*
$\bar{X}$ ± SD	6.92 ±0.29	6.99±0.30	6.02±0.20	6.36±0.25	47.2±6.2	12.3±2.4	5.6±1.6
G1	6.24 ±0.36	6.36±0.30	5.69±0.01	5.77±0.02	40.4±2.8	11.9±1.9	4.1±1.0
G2	6.58 ±0.03	6.55±0.03	5.71±0.01	5.79±0.02	51.8±4.1	11.8±2.6	6.6±1.5
G3	6.56 ±0.06	6.59±0.05	5.71±0.03	5.79±0.03	49.4±4.0	13.1±2.5	6.1±1.0
P	*[4)]	NS	NS	NS	***	NS	***
Sex M[2)]	6.54 ±0.03	6.56±0.03	5.71±0.01	5.79±0.02	46.2±6.4	12.2±2.3	5.5±1.9
F	6.56 ±0.03	6.53±0.03	5.70±0.01	5.78±0.02	48.8±6.0	12.3±2.4	5.6±1.3
P	NS	NS	NS	NS	NS	NS	NS

[1)] G1-Mangalitsa (MNG), G2- Moravka (MO), G3- MNGxMO;
[2)] M-male castrates, F-females;
[3)] pH of the MD- Longissimus dorsi muscle and SM- Semimembranosus muscle; Meat colour of the Longissimus dorsi muscle CIEL*a*b* system;
[4)] NS=P>0.05; *=P<0.05; ***=P<0.001.
Source: Authors' own elaboration

show a lower value of 46.21 cm^2, and in the research of Radović et al. (2017a) higher FA value (51.54 cm^2) compared to our research.

Pork meat quality (Table 5) did not differ statistically considering genotype and sex, in terms of pH value except for the pH_{45}-ML ($P<0.05$). The lightness of colour *L** determines the total amount of light reflected from the surface of the slice of meat. The value of *L** to the greatest extent depends on the marbling of the meat i.e. structure of the meat tissue, pH value of the meat, water holding capacity and the depth of penetration of the light beam. L* values below 43 indicate dark meat. It was found that the animals of the Mangalitsa breed (G1) have darker meat, that is, the determined L* value was 40.4, while a higher value was determined for G2 and G3 (51.8 and 49.4, respectively). Also, the b* value was lower in G1 (4.1) compared to G2 and G3 (6.6 and 6.1). The determined differences for the specified trait were highly statistically significant ($P<0.001$). The pH value results obtained in this study for G2 are similar to the study by Kušec et al. (2017) for the Crna Slavonska breed (reared in the same system-open system), while significantly lower values for L* 51.8:47.0 and b* 6.6:2.0 were found for the meat colour, while a lower a* value was determined compared to our research (11.8:10.9). Similar values were reported by Radović et al. (2017a) for genotypes G1, G2, and G3 with respect to pH45 and pH24 traits of the Longissimus dorsi and Semimembranosus muscles, as well as the colour of the Longissimus dorsi muscle.

CONCLUSION

These back fat thickness values are expected because Mangalitsa belongs to the group of fatty pig breeds, while Moravka is more fertile and meatier compared to Mangalitsa; i.e., Moravka belongs to the group of pigs with combined production performances. Genotype, as a source of variation in carcass quality traits, did not influence ($p > 0.05$) the variation of the examined carcass quality traits except for the surface, depth, and pH45 of M. Longissimus dorsi ($p < 0.05$). Genotype also had an influence on the colour of M. Longissimus dorsi (L* and b*; $p < 0.001$). The pH45 and pH24 values of M. semimembranosus and the pH24 of M. Longissimus dorsi indicated normal meat and were not influenced by genotype or gender ($p > 0.05$). Gender had an influence on the surface of the back fat (FA) and RM-depth of the Longissimus dorsi muscle ($p < 0.05$), whereas, for other sources of variation in carcass quality traits, gender did not have an influence ($p > 0.05$). These results supplement previous research on the quality of crosses and meat of local breeds, which are our treasure, unrepeatable, and important for the preservation of biodiversity. Further monitoring and collection of data on the phenotype and genotype of local breeds are crucial for preserving genetic diversity and developing conservation and breeding strategies for local pig breeds.

The goals and main activities related to Transforming our World: the 2030 Agenda for Sustainable Development (SDG) and the national management and conservation of autochthonous pig breeds (animal genetic resources) in the following period should be focused on the following:

1. End hunger, achieve food security and improved nutrition and promote sustainable agriculture;
2. Protect, restore and promote sustainable use of terrestrial ecosystems and halt biodiversity loss;
3. Development of a national strategy;
4. Improvement of breeding programs;
5. Inclusion of autochthonous breeds in the system of ecological and organic production;
6. Market development for products with protected geographical origin;
7. Development of rural tourism.

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